OPERATING INSTRUCTIONS

for

TYPE 874-GA

ADJUSTABLE ATTENUATOR

DESCRIPTION

The Type 874-GA Adjustable Attenuator is of the waveguide-below-cutoff type operating in the $TE_{1,1}$ mode (inductive coupling). The waveguide is excited by a coaxial transmission line, as shown in Figure 1, and the output voltage is induced in a loop mounted on a sliding plunger. One end of the loop is terminated in a 50-ohm resistor and the other is connected to the output cable. This arrangement makes the output impedance of the attenuator approximately 50 ohms. The attenuation is varied by rotating the barrel which moves the plunger and loop along the tube. The barrel is calibrated in relative attenuation in db. The attenuator can be adjusted from the stop at the minimum attenuation position, which occurs at about -9 db on the calibrated scale, to the stop at the maximum attenuation end of the range, which occurs at about 140 db on the scale. Each revolution of the barrel changes the attenuation 20 db. In most applications the maximum usuable attenuation is limited by leakage from various parts of the driving circuit and not the range of the attenuator.

The method of coupling to the coaxial line permits the attenuator to be used as a standard calibrated attenuator or as a device for coupling a small amount of energy from a high-level circuit for monitoring or measurement purposes without introducing a large discontinuity in the main line.

ERRORS

In all waveguide attenuators, the excitation of modes other than the desired one distorts the theoretical attenuation characteristic, particularly at low attenuation levels. In the Type 874-GA Attenuator, the $TM_{0,1}$ mode (capacitive coupling) is the most serious offender. This mode is attenuated more rapidly with distance from the source end of the waveguide than is the desired mode and its intensity is proportional to the voltage across the exciting line at the coupling point while the intensity of the desired mode is proportional to the current flowing in the exciting line at the point of coupling. The effect of the undesired mode on the attenuation characteristic therefore decreases as the attenuation increases. Since the output from the attenuator is the sum of the voltages generated in the loop by both modes, serious errors can result if the voltage in

the exciting line at the coupling point is high compared to the current; that is, if the impedance is high.

If the exciting line is terminated in its characteristic impedance, for instance with a Type 874-WM Termination Unit, the error resulting from the coupling of the $TM_{0.1}$ mode can be corrected by using Figure 2. The sign of the correction depends on which end of the exciting line is connected to the source of the r-f power. If the source is connected to the end marked with the letter S, use the correction curve labeled NORMAL and subtract the correction found for initial setting of the attenuator from the initial scale reading. Then subtract the correction found for the final setting of the attenuator from the final scale reading. The true attenuation is the difference in the corrected values. If the source is connected to the opposite end, add the corrections read off the curve labeled REVERSED to the indicated values. When these correction charts are used, the indicated relative attenuation is accurate within $\pm$(1.5% + 0.2 db) at frequencies up to 2000 Mc. For accurate results at higher frequencies for small values of attenuation, the method outlined in the following paragraph should be used.

The correction can be eliminated and the indicated relative attenuation made to agree very closely with actual attenuation from -9 db to 140 db on the scale by making the voltage across the line at the minimum coupling point approach zero. This can be accomplished by connecting an adjustable short-circuiting stub line (Type 874-D20 or -D50) to the end of the main line opposite from the source and adjusting it until a voltage minimum appears at the coupling point. The proper adjustment can be easily found by substituting a Type 874-VR and a Type 874-VI Voltmeter Indicator or a Type 874-T and a detector for the attenuator, adjusting the stub until the indicated voltage is minimized, and replacing the attenuator[1]. (If the Type 874-VR is used, the end having the series resistor, which has an R engraved on it, should be connected to the generator.) If the frequency is changed by an appreciable amount, the stub will have to be reset, but a frequency calibration can be marked on the stub to save time if a number of measurements are to be made. At frequencies below 300 Mc, a Type 874-WN Short Circuit can be substituted for the stub, and no adjustments need be made. With the Type 874-WN Short Circuit accurate results can be obtained at scale readings greater than zero. At frequencies below 1500 Mc, the indicated attenuation is accurate at scale readings as low as -9 db and at frequencies between 1500 and 4000 Mc readings above 0 db on the calibrated scale are accurate if the stub is set as previously outlined.

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[1]At first glance it may appear that a simpler method of setting a voltage minimum at the coupling point could be worked out utilizing the difference in the attenuation constants of the two modes. At relatively large attenuation settings the output is closely proportional to the intensity of the desired mode. It might appear that if the attenuator is set to a relatively large value of attenuation, the stub can be properly set by adjusting until maximum output is obtained from the attenuator. Unfortunately a voltage minimum does not occur at a current maximum unless the effective source impedance seen looking back toward the generator from the coupling point is a pure resistance and hence this method cannot be generally used.

At the higher frequencies the attenuation is reduced due to the waveguide approaching its cutoff frequency. To correct for this effect, multiply the indicated attenuation by the factor found in Figure 3 corresponding to the operating frequency.

The output impedance of the attenuator is nominally 50 ohms. However, the impedance varies appreciably with frequency as shown by the plot in Figure 4 of the SWR seen looking back into the output connector for a typical unit. The tolerance on the d-c resistance of the 50-ohm resistor is ±10%.

APPLICATIONS

(1) The attenuator can be used in conjunction with a Type 874-VR Voltmeter Rectifier and a Type 874-VI Voltmeter Indicator to make a signal generator out of an oscillator such as the Type 1208-A or Type 1209-A Unit Oscillator. A block diagram of a typical setup is shown in Figure 5.

In this case the stub is adjusted as indicated in a previous paragraph and the adjustable line[2] (Type 874-LA) is adjusted to obtain a maximum indication from the Type 874-VI Voltmeter Indicator. The voltage indicated with the load connected is the effective open-circuit output voltage, and the source impedance is accurately 50 ohms. The output can be reduced by adjusting the attenuator, the actual voltage at any attenuator setting being the indicated number of db below the original calibrating value.

Since the source impedance is the same as the characteristic impedance of the line, the same effective open-circuit voltage and source impedance are obtained at the end of any length of 50-ohm line connected to the output of the voltmeter-rectifier.[3] If the line is not lossless, the effective open-circuit voltage will be reduced by the loss in the line.

(2) The attenuator can also be used to measure the attenuation of a network by the substitution method as indicated by the block diagram in Figure 6.

Readings of the detector output and attenuator setting are first made without the circuit under test connected. The circuit is then inserted and the attenuator readjusted to give the same detector indications. The attenuation of the unknown circuit is then the difference in the attenuator readings. The pads indicated are used to make the source and load impedances very close to 50 ohms. In many cases, one or both can be omitted.

(3) For monitoring purposes the input line of the attenuator can be connected in series with the line under test without introducing an appreciable reflection or loss. The changes in level in the main line can be accurately measured

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[2]At the lower frequencies, it may be necessary to add lengths of Type 874-L30 Air Line in series with the adjustable line to obtain the maximum output.

[3]Peterson, A.P.G., "Output Systems for Signal Generators," General Radio Experimenter, June 1946, Vol. XXI No. 1.

using the attenuator and an uncalibrated detector which may be 1) a Type 874-VR Voltmeter Rectifier with a d-c microammeter or an audio-amplifier such as the Type 1231-B Amplifier and Null Detector if the signal is modulated; or 2) a high frequency receiver which can be made up of a Type 874-MR Mixer Rectifier, A Type 1208-A Unit Oscillator, and a communications receiver.[4] The SWR introduced in a flat line by the insertion of the attenuator is shown in Figure 7.

[4]Karplus, E., "V-H-F and U-H-F Unit Oscillators," General Radio Experimenter, May 1950, Vol. XXIV No. 12.

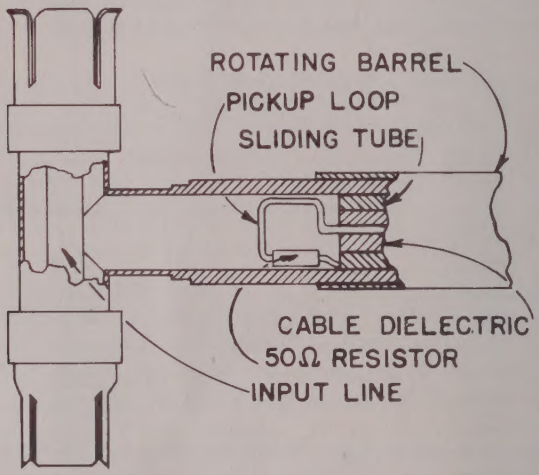

Figure 1. Cutaway view of adjustable attenuator

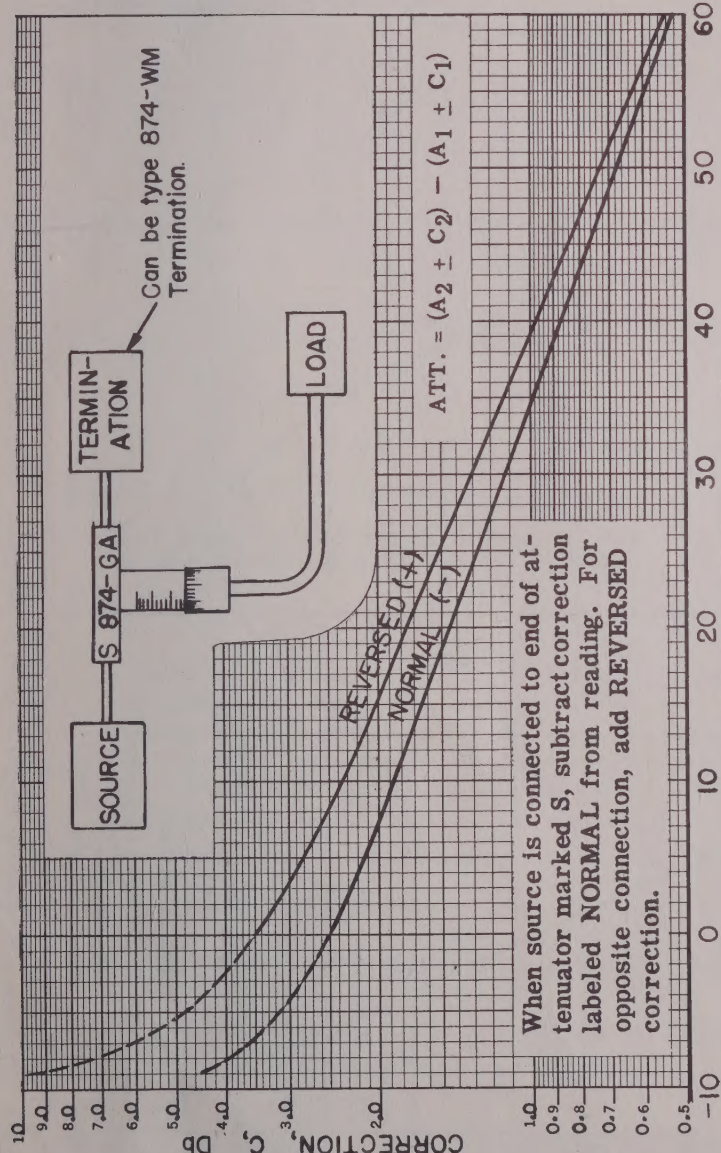

Figure 2. Correction chart for use with Type 874-GA Adjustable Attenuator when exciting line is terminated in its characteristic impedance

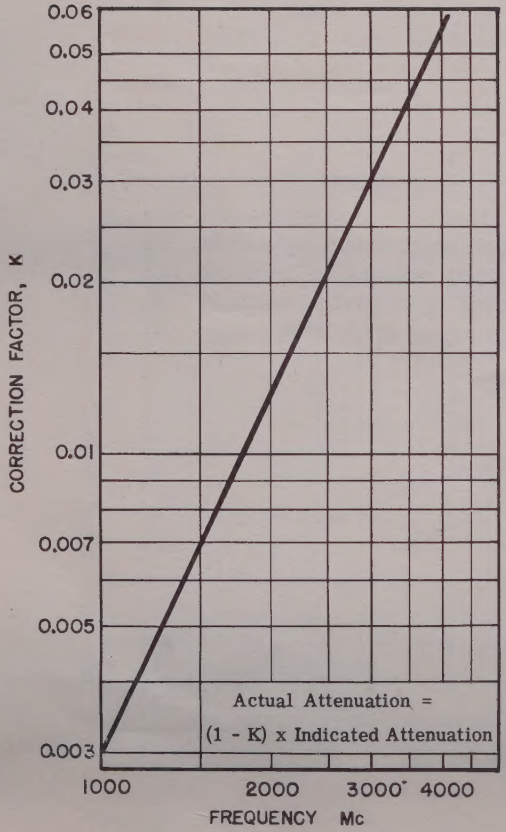

Figure 3. Frequency Correction Factor

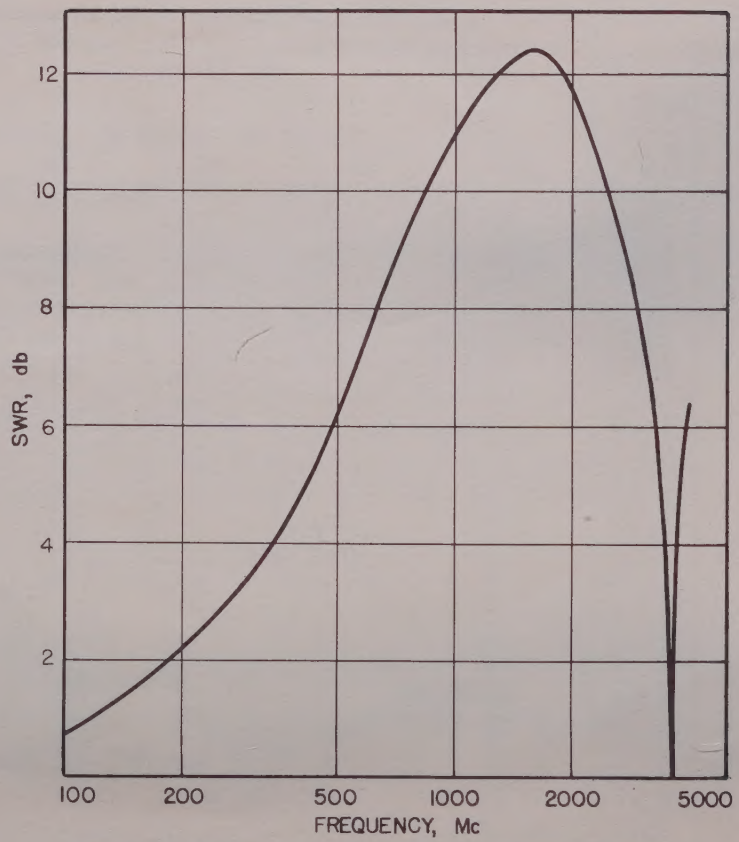

Figure 4. SWR seen looking back into output connector of a typical Type 874-GA Adjustable Attenuator

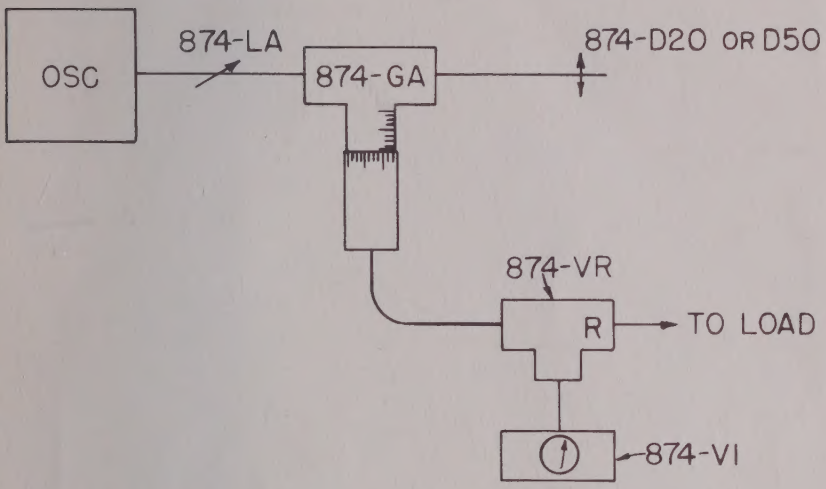

Figure 5. Block diagram of a simple signal generator using the adjustable attenuator and other Type 874 Coaxial Elements

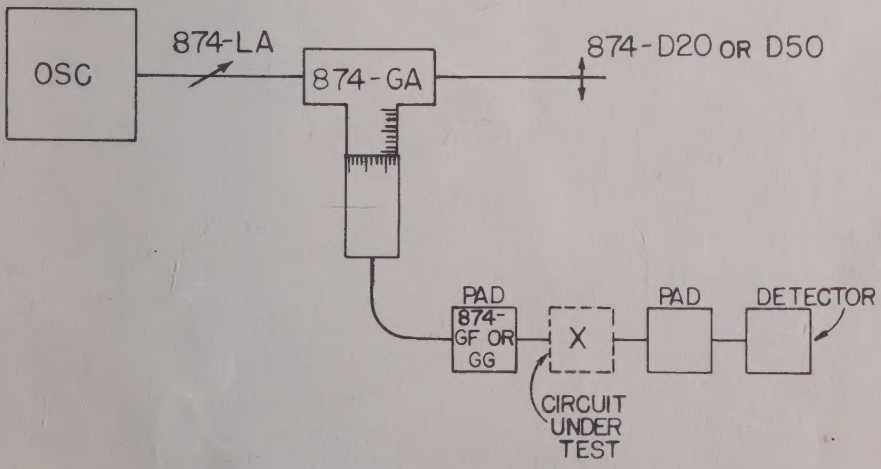

Figure 6. Block diagram of set-up for measuring the attenuation of a network

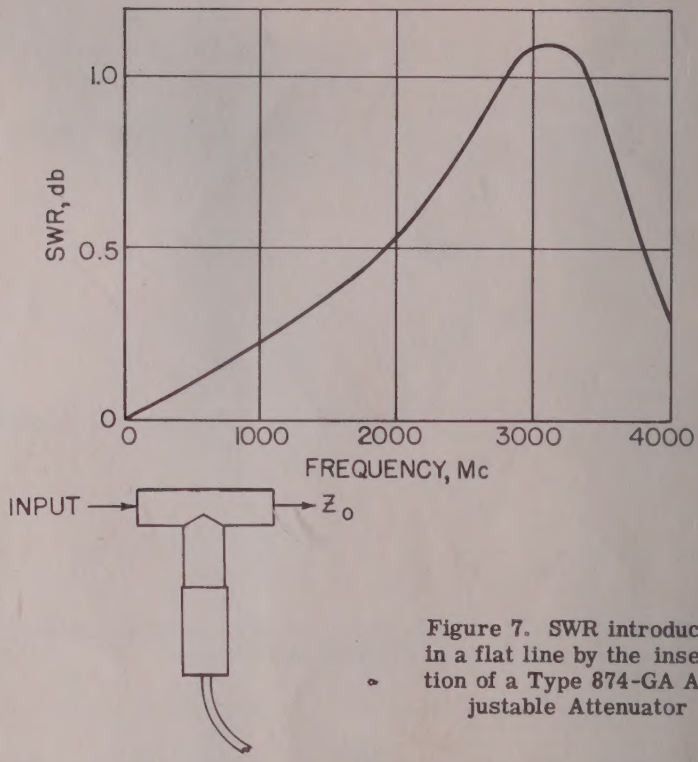

Figure 7. SWR introduced in a flat line by the insertion of a Type 874-GA Adjustable Attenuator

SPECIFICATIONS

Calibrated Range: 120 db - usuable range depends upon shielding between input and output.

Insertion Loss at 1000 Mc:

With input line terminated in 50 ohms.

Minimum - 18 db.

At beginning of accurately calibrated range - 33 db.

With input line terminated in adjustable stub, (to produce voltage minimum under coupling loop),

Minimum - 20 db.

At beginning of accurately calibrated range - 20 db.

Insertion loss for both terminations is approximately inversely proportional to frequency up to 1000 Mc.

Accuracy of Attenuation:

Stub-terminated input, ±(1% of difference in attenuation readings +0.2) db, direct reading.

50-ohm terminated input, ±(1-1/2% of difference in attenuation readings +0.2) db, when corrected. Correction chart supplied.

Waveguide Mode: $TE_{1,1}$; cutoff frequency: 12,300 Mc.

VSWR Introduced into Line: Less than 1.03 at 1000 Mc; less than 1.2 between 1000 and 4000 Mc.

VSWR of Output:

Less than 4 at 1000 Mc.

Less than 5 up to 4000 Mc.

Frequency Range: 100 Mc to 4000 Mc.

Net Weight: 1-1/4 pounds.

U.S. Patents Nos. 2,125,816 and 2,548,457

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